ZAP ENERGY INC.

Sheared Flow Stabilized (SFS) Z-Pinch Performance Improvement

BETHE Kickoff Virtual Workshop
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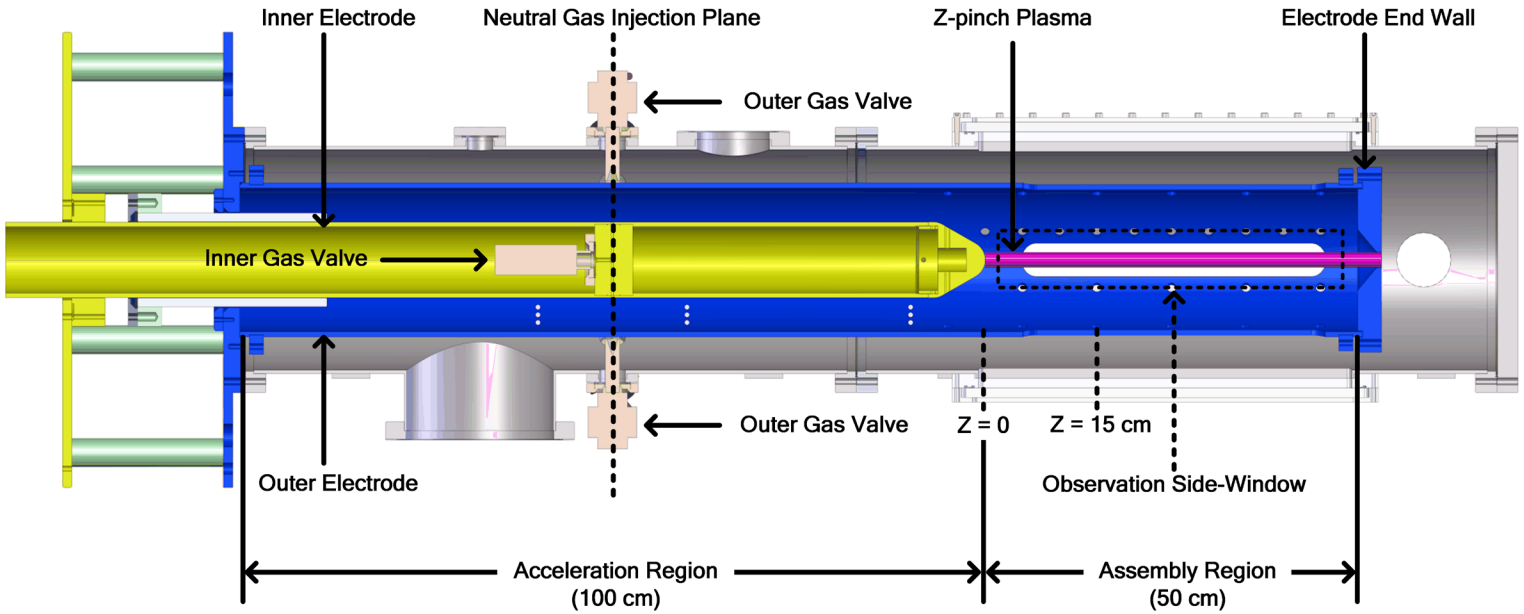
PI: Brian A. Nelson, Chief Technology Officer, Zap Energy Inc.

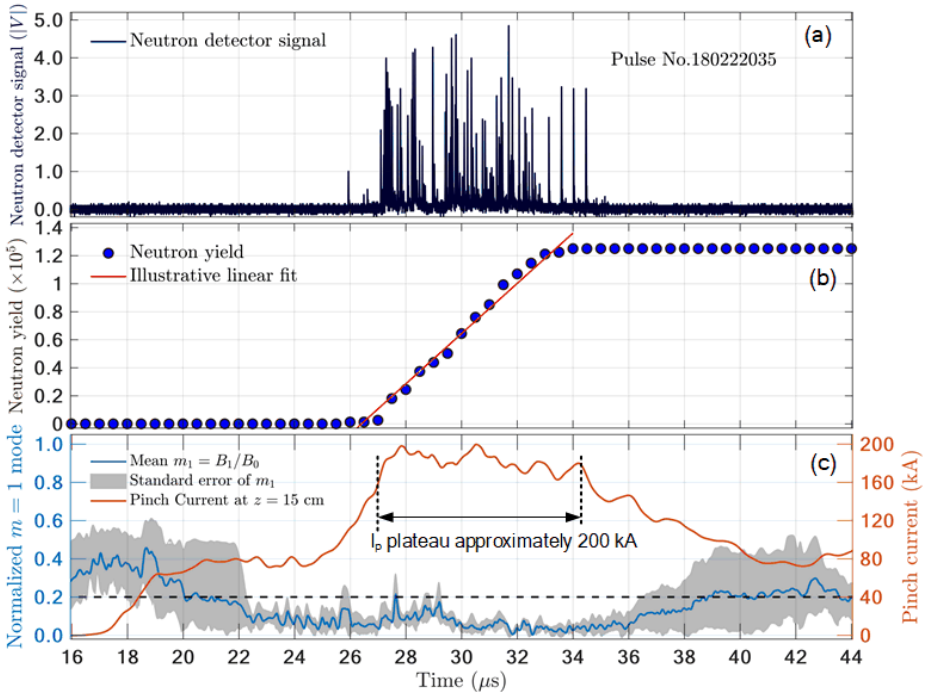
BETHE Team members and roles

- Brian A. Nelson, BETHE PI, Co-Founder & CTO
- Uri Shumlak, Co-Founder & CSO
- Mathias Van Patten, Intern Research Assistant
- Computational PostDoc, TBD

Category A: Improve SFS Z-Pinch Performance 1/2

- The SFS Z-pinch uses a radial shear in an axial flow to stabilize Z-pinches
  - No magnetic field coils nor auxiliary heating (compact and inexpensive)
  - Sustained thermonuclear neutron production ~10 μs in FuZE*





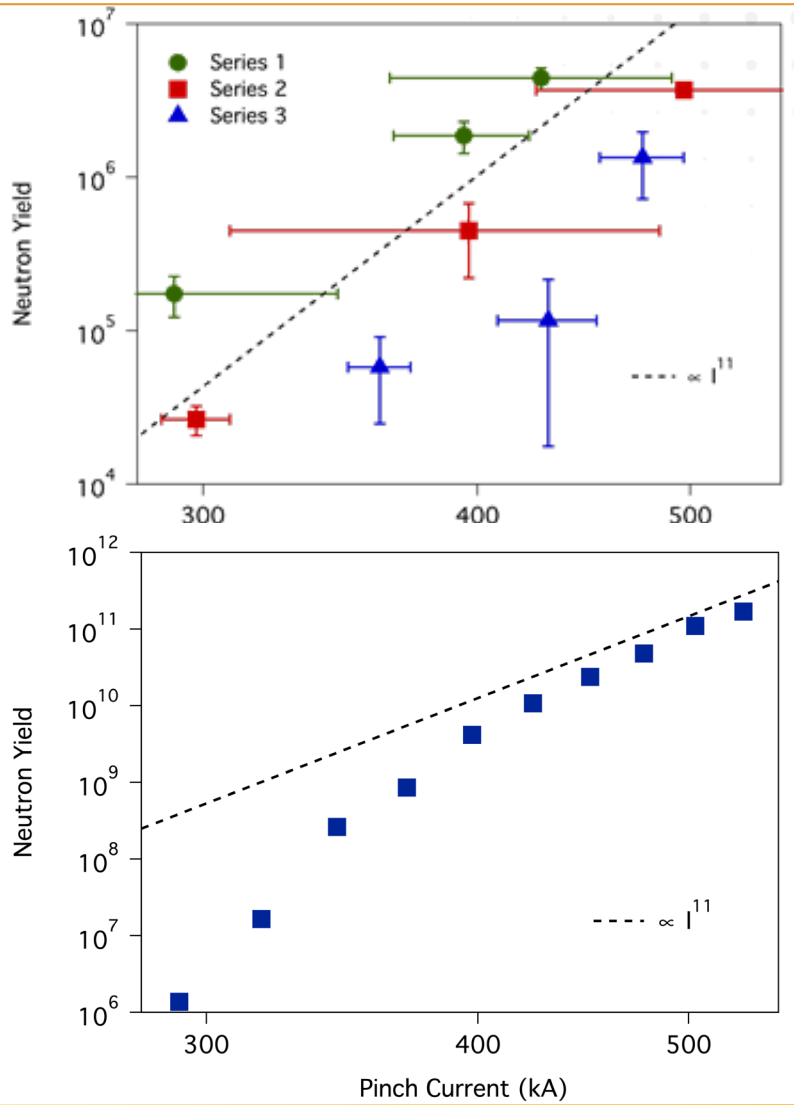
*Zhang *et al. PRL* 2019, Mitrani *et al. NIMA* 2019, Mitrani *et al.* in preparation

Category A: Improve SFS Z-Pinch Performance 2/2

- Integrate improved capabilities into the next Zap Energy SFS Z pinch: FuZE-Q
  - Allow separate sheared-flow formation and pinch compression processes
- Further improvement of $n\ kT\ \tau$ fusion triple product and neutron yield with current*

$$n\ kT\ \tau \propto I^5 \quad \text{and} \quad Y_n \propto I^{11}$$

- Improved diagnostics for higher performance SFS Z pinches
  - Increased resolution for smaller pinches at high current
- High-fidelity modeling and validation with experimental results
  - PMI, electrode durability, improved operational domains, *etc.*



*Shumlak *JoAP* 2020

Major tasks (and technical risks), milestones, and desired project outcomes

- Build and commission new, more capable, SFS Z-pinch FuZE-Q

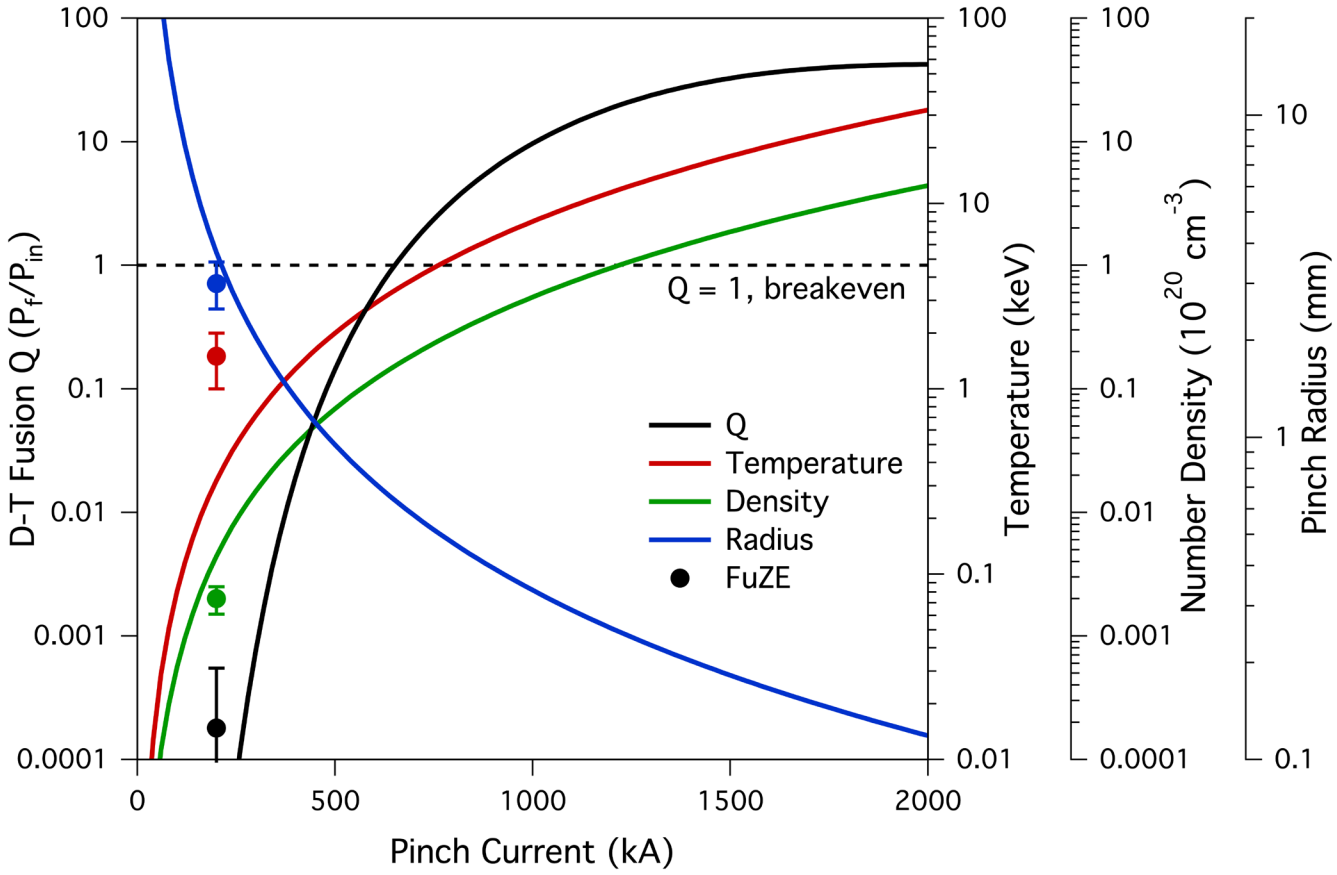
- Improved diagnostics to resolve higher current, higher temperature, higher density, and smaller diameter pinches
  - Higher-resolution spatial- and time-resolved diagnostics for temperature, density, and PMI measurements
  - X-ray & Thomson scattering T_e measurements and imaging (with ARPA-E Diagnostic and Capability Teams)

- High-fidelity computational studies
  - Electrode PMI studies, separate formation/acceleration concepts, validation, *etc.*

- Evaluate SFS Z-pinch concept at higher performance

Key techno-economic metrics of the project (and, if applicable, its commercial fusion-energy application)

- Verify scaling to higher currents
  - Improved $n\,kT\,\tau$
  - Higher-resolution diagnostics
- Computationally evaluate effects of PMI, as well as independent control of acceleration and compression processes
  - Improved electrode designs
  - Improved operational domains
- Evaluate scaling* for SFS Z-pinch reactor and economics
  - Compact, no coils, TBR > 1.1 with liquid PbLi walls, Pth ~ 200 MW**



*Shumlak *JoAP* 2020; **Forbes *et al. FST* 2019